

THE GUNONG BENOM EXPEDITION 1967

8. TICKS (IXODIDAE) OF GUNONG BENOM AND THEIR ALTITUINAL DISTRIBUTION, HOSTS AND MEDICAL RELATIONSHIPS

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8. TICKS (IXODIDAE) OF GUNONG BENOM AND THEIR ALTITUDINAL DISTRIBUTION, HOSTS AND MEDICAL RELATIONSHIPS

By H. HOOGSTRAAL, B. L. LIM, M. NADCHATRAM & G. ANASTOS

SYNOPSIS

Ticks collected on Gunong (Mt.) Benom, an undisturbed forest environment particularly favourable for studying altitudinal distribution (700 to 6916 ft) of tick species occurring in the Malay Peninsula, were *Ixodes granulatus*, *I. simplex*, *Haemaphysalis calvus*, *H. bispinosa*, *H. c. cornigera*, *H. hylobatis*, *H. nadchatrami*, *H. semermis*, *H. traguli*, *H. vidua*, *H. wellingtoni*, *H. asiatica*, *H. doenitzi*, *H. koningsbergeri*, *Dermacentor atrosignatus*, *D. compactus*, *Amblyomma testudinarium*, and *A. geomeydae*.

I. simplex and *H. calvus* were not previously recorded from the Malay Peninsula. *Haemaphysalis centropi* Kohls, 1949, is a synonym of the earlier described *H. doenitzi* Warburton and Nuttall, 1909. The species of *Dermacentor* in Malaya are reported for the first time.

No ticks were collected in mossy forests (5300–5500 ft). One found on a person at 6000 ft may have attached at a lower level. *Dermacentor atrosignatus* comprised 48% of the collections from vegetation between 500 and 2500 ft altitudes and 41% of those from 2600 to 5200 ft. *D. compactus* comprised 16% of collections from vegetation up to 2500 ft, but only 0·2% of those from higher altitudes. *H. nadchatrami* and *H. semermis* comprised 6 and 11%, respectively, of collections from vegetation between 500 and 2500 ft but 54% and 2% respectively, of those from 2600 to 5200 ft. Data are provided for tick parasitism of 28 mammal and bird species on Gunong Benom, for samples obtained by sweeping forest vegetation at different altitudes, and for vertebrates that were not tick-infested.

Species biting human beings were *H. nadchatrami*, *H. semermis*, *H. c. cornigera*, *Dermacentor atrosignatus*, and *A. testudinarium*. This mountain area is eminently suitable for investigating "primitive" cycles of tickborne viruses and rickettsiae in nature and many of the tick species listed are important candidates for epidemiological research. Elsewhere in Malaya, *I. granulatus* has been found to be infected by Langat and Lanjan viruses, *Dermacentor* sp. and *H. semermis* by Lanjan virus, and *H. nadchatrami* by Q fever (*Coxiella burnetii*). Both haemaphysalid species, *Dermacentor* sp. and *I. granulatus* have been implicated in the natural cycle of tick typhus (*Rickettsia* sp.) in Malaya.

INTRODUCTION

MOUNT (Gunong) BENOM offers an exceptional opportunity for investigating the effects of altitude on ecological zonation in Malaya (Whitmore, 1972). The highest peak (6916 ft) in a compact montane formation, Gunong Benom is situated at approximately 4°N in the middle of Malaya between the Main and Eastern Ranges. Forest extending from 700 ft to the peak has been disturbed by logging operations only near the base and in scattered patches up to about 1700 ft. Ecologically, lowland forest merges with montane forest at 2500 ft and montane mossy forest begins at 5300 ft.

During the current Malayan Tick Survey¹, we have obtained considerable data concerning the distribution and host relationships of the ticks inhabitating lowlands and highlands of the Malay Peninsula. However, prior to the Gunong Benom Expedition (Medway, 1972), we had not had the opportunity to compare systematically the effects on tick distribution and incidence of altitudinal factors in a single unbroken, undisturbed Malayan transect such as this. Results from the Gunong

TABLE I
Ticks from vegetation on Gunong Benom, Pahang

Tick species	Number					(%)
	♂	♀	Nymph	Larva	Total	
500–2500 Feet altitude (Lowland forests)						
<i>Dermacentor atrosignatus</i>	103	158	0	0	261	(47.8)
<i>Dermacentor compactus</i>	40	46	0	0	86	(15.8)
<i>Haemaphysalis nadchatrami</i>	19	12	0	0	31	(5.7)
<i>Haemaphysalis semermis</i>	25	37	0	0	62	(11.3)
<i>Haemaphysalis koningsbergeri</i>	3	3	0	0	6	(1.1)
<i>Haemaphysalis hylobatis</i>	1	3	0	0	4	(0.7)
<i>Haemaphysalis calvus</i>	16	18	0	0	34	(6.2)
<i>Haemaphysalis c. cornigera</i>	18	21	3	0	42	(7.7)
<i>Amblyomma testudinarium</i>	7	5	2	0	14	(2.6)
<i>Amblyomma geomydae</i>	0	0	6	0	6	(1.1)
Total	232	303	11	0	546	
2600–5200 Feet altitude (mountain forests)						
<i>Dermacentor atrosignatus</i>	63	109	0	0	172	(41.4)
<i>Dermacentor compactus*</i>	0	1	0	0	1	(0.2)
<i>Haemaphysalis nadchatrami</i>	110	113	0	0	223	(53.6)
<i>Haemaphysalis semermis</i>	3	7	0	0	10	(2.4)
<i>Haemaphysalis hylobatis</i>	0	1	0	0	1	(0.2)
<i>Amblyomma testudinarium</i>	5	4	1	0	9	(2.2)
Total	181	234	1	0	416	
5300–5500 Feet altitude (Mountain mossy forests)						
(No ticks)**	0	0	0	0	0	(0.00)

*Collected at 2700 ft.

**5 persons sweeping 24 March (1500–1800 hrs), 25 March (1000–1500 hrs), 26 March (1100–1400 hrs), 14 January (1400–1800 hrs), 15 January (0900–1300 hrs).

¹The Malayan Tick Survey, which has been in operation since mid-1966, is a collaborative study between the Institute for Medical Research, Kuala Lumpur, the Zoology Department, University of Maryland, and NAMRU-3, Cairo, supported in part by U.S. Army Research and Development Command grant number DADA-17-67-C-7003.

Benom study have been particularly useful in providing material and data for the first author's revisional study of the *Dermacentor* ticks of Southeast Asia and of the biology and distribution of *Haemaphysalis* ticks of the world.²

The University of Malaya - British Museum (Natural History) - sponsored Gunong Benom Expedition, headed by Lord Medway, who has described (1972) previous exploration of the area, expedition aims and operations, and participating organizations and personnel, was in the field from 1 February to 15 April 1967. Members of the George W. Hooper Foundation of the University of California Medical Center, San Francisco, then attached to the Faculty of Medicine, University of Malaya, participated in the expedition and later revisited the mountain for additional collecting (Marchette, 1967; Dr. Richard Garcia, personal communication). Certain members of the Malayan Tick Survey also collaborated with the expedition and worked in the area prior to and following the period the expedition was on Gunong Benom. The names of persons responsible for the excellent tick collections and data reported here are listed at the end of this paper. The outline description of forest zones on northeast Gunong Benom by Whitmore (1972) should be consulted by readers who are particularly concerned with the ecological aspects of this study.

The term Malaya, as used in this paper, refers only to the Malay Peninsula from the Southern border of Thailand to Singapore. In discussions of Borneo, political divisions are not mentioned.

MATERIALS AND METHODS

Vertebrate animals collected by members of the Gunong Benom expedition or the Malayan Tick Survey were routinely inspected for ectoparasites. For ticks, bath towels attached to a stick were also used to flag vegetation at intervals from 700 to 5500 ft. Owing to the absence of ticks between 5300 and 5500 ft, and the cold, wet weather above this altitude, no effort was made to collect material between 5500 ft and the peak at 6916 ft. Actual dates of collection of each specimen are available and will be furnished on request.

RESULTS

The ticks of Malaya have been reviewed by Kohls (1957) and by Audy et al. (1960). Subsequent changes in the taxonomic status of certain *Haemaphysalis* species are mentioned below. The reader is referred to these papers for taxonomic details, which are omitted in this report. Results are presented in tabular form for ticks taken by flagging vegetation at various altitudes (Table 1) and for those from hosts (Table 2), together with a list of vertebrate species that were apparently not tick-infested.

²The *Dermacentor* and *Haemaphysalis* studies are supported in part by contract number 03-005-01 between the U.S. Public Health Service National Institute of Allergy and Infectious Diseases, Bethesda, Maryland, and NAMRU-3, Cairo.

TABLE 2

Ticks from vertebrates on Gunong Benom, Pahang*

500–2500 Feet altitude (Lowland forests)

Vertebrate species	Number examined	Number infested	Tick species (sex/stage)
INSECTIVORA			
<i>Echinosorex gymnurus</i>	1	1	<i>Ixodes granulatus</i> (4♀, 3N, 4L) <i>Amblyomma</i> sp. (1L)
CHIROPTERA			
<i>Penthetor lucasi</i>	1	1	<i>Ixodes simplex</i> (1L)
<i>Rhinolophus stheno</i>	24	11	<i>Ixodes simplex</i> (6♀, 2N, 5L)
<i>Rhinolophus affinis</i>	6	6	<i>Ixodes simplex</i> (3♀, 2N, 4L)
RODENTIA			
<i>Ratufa affinis</i>	7	1	<i>Dermacentor</i> sp. (1N)
<i>Callosciurus caniceps</i>	3	1	<i>Dermacentor atrosignatus</i> (2N)
<i>Sundasciurus tenuis</i>	9	1	<i>Haemaphysalis nadchatrami</i> (2N)
<i>Rhinosciurus laticaudatus</i>	3	1	<i>Haemaphysalis nadchatrami</i> (1N)
<i>Lariscus insignis</i>	3	2	<i>Haemaphysalis koningsbergeri</i> (2N)
<i>Rattus sabanus</i>	40	17	<i>Ixodes granulatus</i> (1♀) <i>Haemaphysalis nadchatrami</i> (3N, 25L) <i>Dermacentor atrosignatus</i> (4N) <i>Dermacentor</i> sp. (2N, 29L)
<i>Rattus muelleri</i>	5	1	<i>Ixodes granulatus</i> (1♂, 1♀)
<i>Rattus bowersii</i>	2	2	<i>Amblyomma</i> sp. (1L) <i>Dermacentor atrosignatus</i> (1N) <i>Dermacentor</i> sp. (16L)
<i>Rattus rajah</i>	7	1	<i>Haemaphysalis nadchatrami</i> (1N) <i>Dermacentor</i> sp. (1L)
Rodent burrow	40	1	<i>Haemaphysalis nadchatrami</i> (1N) <i>Ixodes granulatus</i> (12L)
CARNIVORA			
<i>Felis bengalensis</i>	1	1	<i>Haemaphysalis asiatica</i> (1♂) <i>Haemaphysalis koningsbergeri</i> (14♂)
<i>Arctogalidia trivirgata</i>	1	1	<i>Haemaphysalis semermis</i> (1♂)
<i>Arctictis binturong</i>	1	1	<i>Haemaphysalis koningsbergeri</i> (2♂) <i>Haemaphysalis koningsbergeri</i> (26♂, 2♀) <i>Haemaphysalis semermis</i> (1♂)
<i>Hemigalus derbyanus</i>	1	1	<i>Haemaphysalis hylobatis</i> (2♂) <i>Haemaphysalis koningsbergeri</i> (1♂)
<i>Paradoxurus hermaphroditus</i>	1	1	<i>Haemaphysalis vidua</i> (3N, 26L)
Domestic dog (Lord Medway)	—	—	<i>Haemaphysalis koningsbergeri</i> (1♀) <i>Dermacentor</i> sp. (4L)
Domestic dogs (aborigine village)	15	6	<i>Haemaphysalis koningsbergeri</i> (7♂, 8♀) <i>Haemaphysalis semermis</i> (3♂) <i>Haemaphysalis bispinosa</i> (8♂, 5♀, 4N) <i>Haemaphysalis koningsbergeri</i> (3♂, 9♀)

Vertebrate species	Number examined	Number infested	Tick species (sex/stage)
ARTIODACTYLA			
<i>Tragulus javanicus</i>	4	4	<i>Dermacentor</i> sp. (1N) <i>Haemaphysalis nadchatrami</i> (4N) <i>Haemaphysalis semermis</i> (1♂, 2N, 1L) <i>Haemaphysalis traguli</i> (1♂, 2♀, 5N, 5L) <i>Haemaphysalis ?nadchatrami</i> (1L) <i>Amblyomma testudinarium</i> (1N) <i>Dermacentor atrosignatus</i> (27♂, 9♀) <i>Dermacentor compactus</i> (11♂, 5♀) <i>Haemaphysalis nadchatrami</i> (18♂, 5♀) <i>Haemaphysalis semermis</i> (2♂, 1♀)
<i>Tragulus napu</i>	1	1	
<i>Sus scrofa</i>	2	2	
AVES			
<i>Centropus sinensis eurycercus</i>	2	2	<i>Amblyomma</i> sp. (1N) <i>Amblyomma geomeydae</i> (1N) <i>Haemaphysalis doenitzi</i> (1♂) <i>Haemaphysalis doenitzi</i> (2L) <i>Haemaphysalis wellingtoni</i> (2N, 1L) <i>Haemaphysalis wellingtoni</i> (2♂, 10L) <i>Amblyomma</i> sp. (1N) <i>Amblyomma testudinarium</i> (1N) <i>Dermacentor atrosignatus</i> (1N) <i>Haemaphysalis c. cornigera</i> (1♀) <i>Haemaphysalis nadchatrami</i> (2♀) <i>Haemaphysalis semermis</i> (1♂, 2N) <i>Amblyomma testudinarium</i> (1♂, 2♀) <i>Dermacentor atrosignatus</i> (1♂, 1N) <i>Haemaphysalis nadchatrami</i> (2♀) <i>Haemaphysalis semermis</i> (2♀)
<i>Dendrocopos m. moluccensis</i>	1	1	
<i>Argusianus argus</i>	1	1	
<i>Lophura erythrophthalma</i>	1	1	
<i>Anthracoboceros malayanus</i>	1	1	
HUMAN BEINGS (biting)**			
HUMAN BEINGS (crawling on)			
2600-6000 Feet altitude (Mountain forests)			
RODENTIA			
<i>Rattus inas</i> (3600 ft)	4	1	<i>Haemaphysalis nadchatrami</i> (1N)
HUMAN BEING (biting, 6000 ft)**			<i>Haemaphysalis nadchatrami</i> (1♀)
HUMAN BEING (crawling on, 3000 ft)			<i>Haemaphysalis hylobatis</i> (1♀)

*The 243 vertebrates (representing 53 forms) inspected and not found to be tick infested, and their numbers (in parentheses), were:

500-2500 Feet altitude (Lowland forests)

PRIMATES. *Tupaia minor* (1), *T. glis* (2), *Ptilocercus lowii* (2), *Nycticebus coucang* (1), *Macaca fascicularis* (1), *Presbytis obscurus* (5).

CHILOPTERA. *Cynopterus brachyotis* (11), *C. hoyfieldi* (22), *Eonycteris spelaea* (18), *Chironax melanolecephalus* (1), *Macroglossus lagochilus* (6), *Balionycteris maculata* (3), *Rhinolophus macrotus* (2), *R. refulgens* (12), *Emballonura monticola* (12), *Hipposideros diadema* (2), *H. galeritus* (2).

RODENTIA. *Hylopetes spadiceus* (4), *Pteromyscus pulverulentus* (1), *Petaurus petaurista* (11), *P. elegans* (4), *Aeromys tephromelas* (4), *Iomys horsfieldi* (5), *Sundasciurus lowi* (4), *S. tenuis* (8), *S. hippocampus* (2), *Callosciurus notatus* (14), *C. nigrovittatus* (4), *C. caniceps* (1), *C. prevosti* (1), *Rhinosciurus laticaudatus* (2), *Lariscus insignis* (1), *Ratufa bicolor* (6), *R. affinis* (6), *Rattus cremoriventer* (7), *R. sabanus* (15), *R. bowersii* (1), *R. rajah* (6), *R. inas* (3), *R. canus* (2), *R. whiteheadi* (6), *Chiropodomys gliroides* (1).

REPTILIA. *Varanus salvator* (1), *V. radicollis* (1), *Gonocephalus boreensis* (1).

AVES. *Otus rufescens* (1), *Chrysocolaptes validus* (1), *Arachnothera longirostra* (1), *Anorrhinus galeritus carinatus* (1).

2600-5300 Feet altitude (Mountain forests)

RODENTIA. *Sundasciurus tenuis tahan* (3), *Callosciurus flavimanus* (1), *Rattus edwardsi* (7), *R. tiomanicus jalorensis* (3).

**Also see remarks in text on larvae (presumably *A. testudinarium*), infesting persons at 3000 to 4000 foot altitudes during the wet season but not during the dry month of February.

Ixodes granulatus Supino

I. granulatus was collected at 700 and 800 ft from the single moonrat (Insectivora, Erinaceidae, *Echinosorex gymnurus*) and from 2 rodents, *Rattus sabanus* and *R. muelleri*. The moonrat, trapped on 28 February beside a stream, was parasitized by 4 female *I. granulatus* on the dorsum and 3 nymphs and 4 larvae on the thighs and belly. One male and 1 female infested 1 of 5 *R. muelleri* (3 March) and 1 female infested 1 of 25 *R. sabanus* (12 January). Twelve larvae resting on the roof of a rodent burrow dropped to a black plate (used for collecting chiggers) a few moments after the plate was inserted by Nadchatram into 1 of 40 burrows on Gunong Benom. Notably, the infestation rate of this tick species on the mountain at the times of collection was low; squirrels and several other rodents were not infested.

I. granulatus commonly parasitizes small mammals, and sometimes birds, living on the ground or in trees in forests from Southeast Asia (southern China, Vietnam, Okinawa, Borneo, Indonesia) to eastern India (Assam). The life cycle of this 3-host tick under laboratory conditions was described by Nadchatram (1960). This is the only Malayan tick species in which each developmental stage parasitizes rodents. The nidicolous behaviour of *I. granulatus* has been confirmed by Nadchatram in several areas of Malaya (unpublished data.)

I. granulatus from *Rattus muelleri* and *R. sabanus* in the Ulu Langat Forest Reserve, Selangor, was the original source of the virus causing Langat encephalitis of humans (Smith, 1956; Hoogstraal, 1966). The natural history of Langat virus remains to be studied. *I. granulatus* is also involved in the cycles of tick typhus (*Rickettsia* sp.) and Q fever (*Coxiella burnetii*) in climax forests of Malaya (Marchette, 1966). Specimens from Trengganu have yielded Lanjan virus (N. J. Marchette, personal communication). Only a single specimen of *I. granulatus* has been recorded biting man in Malaya. Thus, this species plays no important direct role in the epidemiology of human disease. However, many other ticks, among them species that more or less frequently infest human beings, feed on the same hosts and may acquire pathogens circulated in a *granulatus* - rodent - *granulatus* cycle and transmit these disease agents to other hosts during feeding in subsequent developmental stages. The potential indirect epidemiological role of *I. granulatus* should be especially interesting to investigate.

Ixodes simplex Neumann

Bats parasitized by *I. simplex* were *Penthetor lucasi* (1 larva from 1 examined, 3600 ft), *Rhinolophus stheno* (6 females, 2 nymphs, 5 larvae, from 11 of 24 examined between 700 and 900 ft), and *R. affinis* (3 females, 2 nymphs, 4 larvae, from 6 of 6 examined at 1500 ft). Eleven other bat species (91 specimens) between 500 and 2500 ft were free of ticks. These are the first published records of *I. simplex* from Malaya and from the genus *Penthetor*.

I. simplex infests many microchiropteran bats, chiefly in the genera *Rhinolophus*, *Myotis*, and *Miniopterus*, in Africa, Europe, Asia and Australia. Other (unpublished)

Malayan records are from *R. stheno* and *Miniopterus medius* at Karak and Fraser's Hill, Pahang. The disease relationships of *I. simplex* have not been investigated.

***Haemaphysalis calvus* Nuttall and Warburton**

Sixteen male and 18 female *H. calvus* were found on lowland forest vegetation in Kuala Kerau and Kuala Lompat Forest Reserves. This species is known only from the original collection from a buffalo in northern Borneo, and from our collections (unpublished) from forest vegetation in Kedah, Pahang, and Selangor, from a tame sambar deer (*Cervus unicolor*) and a tiger [British Museum (Natural History)] in Pahang, and from a bear near Bangkok, Thailand. Disease relationships have not been studied.

***Haemaphysalis bispinosa* Neumann**

Eight males, 5 females, and 4 nymphs were taken from 6 of 15 domestic dogs examined in Kuala Kerau Forest Reserve in September 1966. These dogs belonged to aborigine villagers and should be recognized as a source distinct from Lord Medway's pet dog, which accompanied Gunong Benom Expedition members and yielded ticks characteristic of wild forest-dwelling carnivores.

In Malaya, *H. bispinosa* shows all the biological features of an introduced parasite, being associated entirely with domestic animals (Hoogstraal et al., 1969). In its homeland, Ceylon, India, southern Nepal, and western Burma, *H. bispinosa* commonly parasitizes wild and domestic birds and mammals. The long list of disease relationships attributed to this species in much literature from Asia, Australia, New Zealand, Japan, and Pacific islands is completely erroneous, having been assembled from studies of misidentified ticks (Hoogstraal et al., 1968). The true disease relationships of *H. bispinosa* remain to be determined.

***Haemaphysalis cornigera cornigera* Neumann**

Specimens collected in Kuala Kerau and Kuala Lompat Forest Reserves at the southeast base of Gunong Benom by the Malayan Tick Survey were: (September 1966) 16 males, 13 females, 3 nymphs from forest vegetation, 1 female, biting person; (April 1968); 2 males, 8 females from forest vegetation.

H. c. cornigera is widely but apparently erratically distributed in Malayan forests, where adults parasitize various kinds of deer, and wild pigs and carnivores. Nymphs and larvae feed on forest rodents. This parasite is common in Borneo and Indonesian islands. Its northern distributional limits and disease relationships remain to be investigated.

Haemaphysalis hylobatis Schulze

Eight specimens were taken, 2 males from the bear cat, *Arctictis binturong*, at 700 ft, 1 female crawling on a man at 3000 ft, 1 male and 3 females from lowland forest vegetation, and 1 female from mountain forest vegetation (2700 ft).

H. hylobatis is an infrequently encountered tick of Malaya and Sumatra, and the 8 from Gunong Benom comprise the largest known number from any single locality. This deep-forest parasite, infests monkeys, man, and carnivores, including domestic dogs, in Pahang, Selangor, and Kedah, Malaya, and in Sumatra, Indonesia. A female reared from a nymph infesting *Rattus surifer* in Selangor (Audy et al., 1960) is the only previously published record of this species in Malaya, and the only available data for immature stage hosts. The disease relationships of *H. hylobatis* have not been studied.

Haemaphysalis nadchatrami Hoogstraal, Trapido and Kohls

Collections from sweeping forest vegetation and from hosts (examined/infested) at various altitudes are as follows:

- Rattus sabanus* (40/5), 700 to 950 ft, 3 nymphs, 25 larvae
- Rattus bowersii* (2/1), 800 ft, 1 nymph
- Rattus rajah* (7/1), 1700 ft, 1 nymph
- Rattus inas* (4/1), 3600 ft, 1 nymph
- Sundasciurus tenuis* (9/1), lowlands, 2 nymphs
- Rhinosciurus laticaudatus* (3/1), 800 ft, 11 nymphs
- Sus scrofa*, (2/2) 800 and 1400 ft, 18♂, 5♀
- Tragulus napu* (1/1), lowlands, 1 larva (tentative identification)
- Tragulus javanicus* (4/2), lowlands, 4 nymphs
- Domestic dogs (aborigine village) (15/2), lowlands, 1♂, 1♀
- Man (biting), 750 and 6000 ft, 2♀
- Man (crawling on), 750 ft, 1♀
- Vegetation, 500 to 2500 ft, 23♂, 22♀
- Vegetation, 2600 to 5200 ft, 110♂, 113♀

H. nadchatrami larvae and nymphs feed on forest rodents and other small mammals. Usually rather few are collected from hosts, presumably owing to especially short periods of parasitism. Adults feed on wild pigs, deer, carnivores, and man. As usual, the 2 wild pigs (*Sus scrofa*) examined were infested by a number of *H. nadchatrami* adults. Sweeping forest vegetation in all parts of Malaya almost always yields questing adults of this species. Notably, adults were much more numerous on vegetation on Gunong Benom at 2600 ft and above than below this elevation (Table 1). All samples, particularly those from higher elevations, were at the upper range of robustness for this species. The Gunong Benom forest environment is obviously ideal for *H. nadchatrami*. The comparative incidence in Malaya of this species and of *H. semermis* is discussed in the section on the latter species.

One of the 2 females biting humans was attached to the ankle, under the sock; a large patch of host skin remains surrounding the hypostome. The second discovered on a person near camp 5 at 6000 ft, may have attached at a lower altitude.

H. nadchatrami, a common forest dweller from central Thailand through the Malay Peninsula to Borneo, Java, Sumatra, and adjacent islands of Indonesia (Hoogstraal, Trapido, and Kohls, 1965), also occurs in the Phillipines on Palawan Island near Borneo (Hoogstraal, Kohls, and Parrish, 1968). In Malaya, adults have been found the year around. While there is probably a seasonal peak in population numbers, this has not yet been demonstrated.

Owing to its ubiquity, wide range of immature and adult stage hosts including man, and year-round feeding activity, *H. nadchatrami* is highly suspect as a reservoir and vector of viruses and rickettsiae. The "Haemaphysalis spp." in Marchette's (1966) study of Malayan tick typhus obviously consisted of many *H. nadchatrami* (Hoogstraal, 1967). Specimens of this species from Trengganu have yielded *Coxiella burnetii*, the agent of Q fever (N. J. Marchette, personal communication). During the Malayan Tick Survey, 7 males and 4 females, in addition to those listed here, were collected while biting man.

Haemaphysalis semermis Neumann

Collections from sweeping forest vegetation and from hosts (examined/infested) at various altitudes are as follows:

Rattus bowersii (2/2), 800 ft, 3 nymphs, 1 larva

Felis bengalensis (1/1), 800 ft, 1♀

Arctictis binturong (1/1), 700 ft, 1♂

Domestic dog (Lord Medway's), 700 ft, 3♂

Domestic dogs (aborigine village) (15/6), lowlands, 8♂, 11♀, 5 nymphs

Sus scrofa (2/2), 800 and 1400 ft, 2♂, 1♀

Tragulus javanicus (4/1), lowlands, 1♂, 2 nymphs, 1 larva

Man (biting), 800 ft, 1♂, 2 nymphs

Man (crawling on), 700 and 1000 ft, 3♀

Vegetation, 500 to 2500 ft, 47♂, 53♀

Vegetation, 2600 to 5200 ft, 3♂, 7♀

The host range of *H. semermis* and *H. nadchatrami* is the same, though preferred hosts appear to be carnivores for *semermis* and wild pigs for *nadchatrami*. The 2 species are practically always sympatric in Malaya, and often on the same hosts. Of the 2259 adults of these 2 species in our Malayan collections, 1589 (70%) are *nadchatrami* and 670 (30%) are *semermis*. Of the 427 adults of these 2 species from Gunong Benom, 286 (67%) are *nadchatrami* and 141 (33%) are *semermis*.

The distribution of *H. semermis*, from southern Thailand through the Malay Peninsula and adjacent islands to Borneo and Sumatra, is almost the same as that of *H. nadchatrami* (Hoogstraal, Trapido, and Kohls, 1965).

The remarks on potential medical relationships of *H. nadchatrami* apply equally to *H. semermis*. Specimens of *H. semermis* from Trengganu have yielded Lanjan virus (N. J. Marchette, personal communication).

Haemaphysalis traguli Oudemans

The 4 larger mouse-deer, *Tragulus javanicus*, examined in the lowland forests of Gunong Benom were infested by 1 male, 2 females, 5 nymphs, and 5 larvae of *H. traguli*. (The single smaller mouse-deer, *T. napu*, was parasitized by only a larva of *H. ?nadchatrami*.)

Adults and immature stages of *H. traguli* commonly feed on *Tragulus javanicus* and *T. napu* in forests of Malaya, and also in Indonesia, Borneo, Thailand, and Burma (Hoogstraal, 1966). The subgeneric position of this and the related *H. vidua* is uncertain. The disease relationships of *H. traguli* have not been investigated.

Haemaphysalis vidua Warburton and Nuttall

Three nymphs and 26 larvae of *H. vidua* were taken on a banded palm civet, *Hemigalus derbyanus*, at 900 ft.

This rare tick is known only from various species of civets (Viverridae) in Pahang, Malaya, and near Kalabakan, Borneo (Hoogstraal, 1962, 1964). Disease relationships have not been studied.

Haemaphysalis wellingtoni Nuttall and Warburton

Two nymphs and 1 larva were taken from an argus pheasant, *Argusianus argus*, in lowland Kuala Lompat Forest Reserve on 12 March 1966. Two males and 10 larvae were found among the ear coverts of a crestless fire-back pheasant, *Lophura erythrophthalma*, in the same locality the same week.

H. wellingtoni ranges from Ceylon, Andaman Islands, and India through southern Nepal, Burma, Thailand, Vietnam, and Malaya, to Borneo and Indonesia (reports from New Guinea are incorrect). All stages typically parasitize wild and domestic gallinaceous birds. Other ground-feeding birds, and sometimes small mammals, are less frequently infested. The migratory habits of some hosts undoubtedly account for the extraordinarily wide distribution of *H. wellingtoni* and specimens have been found in Japan on a migrant gray thrush, *Turdus c. cardis*.

The disease relationships of *H. wellingtoni* unfortunately have not been studied. This species is an especially interesting candidate for arbovirus investigation.

***Haemaphysalis asiatica* (Supino)**

A single male of this uncommon species was taken on a leopard cat, *Felis bengalensis*, at 750 ft.

H. asiatica [= *H. dentipalpis* Warburton and Nuttall] occurs in forests of Burma, southern China, Vietnam, Thailand, peninsular Malaya, and Borneo, where its chief hosts are civets (Viverridae) and, less often, other carnivores (Hoogstraal and Trapido, 1966). The disease relationships of this species have not been studied.

***Haemaphysalis doenitzi* Warburton and Nuttall**

Two of the 9 birds examined on Gunong Benom were infested by *H. doenitzi*. These were a coucal, *Centropus sinesis*, by a male (700 ft), and a short-tailed babbler, *Trichastoma malaccense*, by 2 larvae (1500 ft).

H. doenitzi adults and immature stages infest birds in forests from Ceylon and southern India to Borneo, Indonesia, New Guinea, southern China, Laos, Vietnam, Taiwan, and southern Japan (Hoogstraal, unpublished data). Coucals, gallinaceous birds, and other birds that feed on or close to the ground are frequent hosts. Some records from Thailand and Laos are from mammals (leporids and domestic dogs.) *H. centropi* Kohls (1949) is a synonym of *H. doenitzi* Warburton and Nuttall (1909) (Hoogstraal, unpublished). The disease relationships of this widely-ranging species unfortunately have not been investigated.

***Haemaphysalis koningsbergeri* Warburton and Nuttall**

Collections from sweeping forest vegetation and from hosts (examined/infested) are as follows:

- Lariscus insignis* (3/2), 700 and 800 ft, 2 nymphs (tentative identification)
- Felis bengalensis* (1/1); 800 ft, 1♂
- Arctiogalidia trivirgata* (1/1), 750 ft, 2♂
- Arctictis binturong* (1/1), 700 ft, 2♂, 2♀
- Hemigalus derbyanus* (1/1), 900 ft, 1♂
- Paradoxurus hermaphroditus* (1/1), lowlands, 1♀
- Domestic dog (Lord Medway's), 750 and 800 ft, 7♂, 8♀
- Domestic dogs (aborigine village) (15/6), lowlands, 3♂, 9♀
- Vegetation, 500 to 2500 ft, 3♂, 3♀

Adults of *H. koningsbergeri* are common parasites of all wild carnivores and of domestic dogs in Malayan forests. Exceptional hosts (unpublished) are the mouse-deer (*Tragulus javanicus* and *T. napu*), wild pig (*Sus scrofa*), pangolin (*Manis javanica*), and domestic goat. A single record, possibly erroneous, is from domestic

fowl. Among our numerous records of this species, none is from man. The immature stages have not been reared in the laboratory and identification of nymphs and larvae, from squirrels and *Rattus*, is tentative.

Adults are frequently obtained by sweeping forest vegetation, but in comparatively small numbers that appear not to indicate the true incidence of *H. koningsbergeri* in Malayan forests. The questing position and location of adults on vegetation, possibly closer to the ground than usually reached in sweeping, should be investigated.

The range of this species includes Borneo, Java, Sumatra, and nearby islands. It would be interesting to know the capacity of *H. koningsbergeri* to transmit *Babesia* spp. among carnivores and to serve as a vector of viruses and rickettsiae.

"*Dermacentor auratus* group"

The true *D. auratus* Supino is rare in Malaya. We have records of *D. auratus* only from Johore (Bekok Forest Reserve, Gunong Sumalayang, and Gunong Beremban), Trengganu (Bukit Kedap Forest Reserve and Bukit Bintang Besut), Perak (Sungei Klah Forest Reserve), and Pahang (Petoh Forest Reserve). The "*D. auratus*" or "*D. auratus* group" ticks earlier reported in literature on tickborne pathogens in Malaya refer in fact to *D. astrosignatus* or *D. compactus*, or to both, but not to *D. auratus* (*sensu strictu*). *Dermacentor* ticks are involved in the cycles of tick typhus (*Rickettsia* sp.) and of Q fever (*Coxiella burnetii*) in Malayan climax forests (Marchette, 1966). Immature *Dermacentor* from rodents from Binkit Lanjan, 7 miles from Kuala Lumpur, provided the first isolation of Lanjan virus (Smith et al., 1967).

The following specimens from Gunong Benom cannot be identified to species and are considered as "*Dermacentor* sp."

Ratufa affinis (7/1), 1200 ft, 1 nymph

Rattus sabanus (40/11), 700 to 2200 ft, 2 nymphs, 29 larvae

Rattus rajah (7/1), 1700 ft, 1 larva

Rattus bowersii (2/1), 800 ft, 16 larvae

Tragulus javanicus (4/1), lowlands, 1 nymph

Domestic dog (Lord Medway's), 700 ft, 4 larvae

***Dermacentor astrosignatus* Neumann**

Collections from sweeping forest vegetation and from hosts (examined/infested) are as follows:

Callosciurus caniceps (3/1), 700 ft, 2 nymphs

Rattus sabanus (40/11), 700 to 2200 ft, 4 nymphs

Rattus bowersii (2/1), 800 ft, 1 nymph

- Sus scrofa* (2/2), 800 and 1400 ft, 27♂, 9♀
 Man (biting), 1700 ft, 1 nymph
 Man (crawling on), 750 and 2500 ft, 1♂, 1 nymph
 Vegetation, 500 to 2500 ft, 161♂, 243♀
 Vegetation, 2600 to 5200 ft, 63♂, 109♀

These 613 adult specimens comprise 84% of the 731 adult *Dermacentor* ticks taken on Gunong Benom (see also Tables 1-3).

The wild pig, *Sus scrofa*, appears to be the chief host of all adult *Dermacentor* in Malaya, and probably of most if not all *Dermacentor* species of tropical Asia. *Sus scrofa* is the most common and generally distributed large mammal in Malayan forests. In the absence of wild pigs, *Dermacentor* ticks would probably be rare in this environment. The 2 wild pigs examined on Gunong Benom yielded 52 adult *Dermacentor*, of which 36 (69%) were *D. atrosignatus* and 16 (31%) *D. compactus*. The 530 wild pigs examined throughout Malaya (Table 3) yielded 8294 adult *Dermacentor*, of which 5498 (66%) were *D. atrosignatus* and 2796 (34%) *D. compactus*. More males (61%) than females (39%) were found on wild pigs owing to the male's longer attachment period and the female's shorter feeding period. In collections of questing adults from Malayan forest vegetation, females (58%) outnumbered males (42%) (Table 3), as they did on Gunong Benom.

TABLE 3

Adult *Dermacentor atrosignatus* and *D. compactus* specimens from all Malayan sources (Hoogstraal collection, 20 April 1969)

Source	<i>D. atrosignatus</i>		<i>D. compactus</i>		Total ♂ & ♀		Total adults
	♂	♀	♂	♀	♂	♀	
Vegetation	3,725	4,756	1,631	2,650	5,356	7,406	12,762
<i>Sus scrofa</i> (530)	3,365	2,133	1,700	1,096	5,065	3,229	8,294
Other hosts (27)	22	43	7	14	29	57	86
Human beings (8)							
crawling on	3	2	0	1	3	3	6
biting	0	1	1	0	1	1	2
Total	7,115	6,935	3,339	3,761	10,454	10,696	21,150
% adults		66		34			

Immature-stage hosts of *Dermacentor* ticks in Malaya are various small size mammals such as insectivores, squirrels and other rodents, carnivores, muntjac, mouse-deer, domestic goats and dogs, and man. Our data for about 800 Malayan nymphs and larvae are not sufficiently extensive or representative to permit discussion of comparative importance of different mammal species as immature-stage hosts. Human beings are seldom recorded as hosts in Malaya in our data and by

Audy *et al.* (1960). This is in marked contrast to the incidence of human infestation by the true *D. auratus* (Supino) in India and the terai (lowlands) of Nepal (Hoogstraal, 1970).

Most *Dermacentor* specimens in our Malayan tick collections are from altitudes below 2500 ft. On Gunong Benom, the 2500 ft altitudinal level appears to be the upper limit of distribution of *D. compactus*, except for an occasional straggler to 2700 ft. On this mountain, tick collections from vegetation up to 2500 ft consisted of 261 (75%) *D. atrosignatus* and 86 (25%) *D. compactus* (Table 1). Above this level, however, these percentages were 41 and 0·24, respectively. The only *D. compactus* specimen taken in the montane forest range was a female at 2700 ft.

Different altitudinal distribution results for *Dermacentor* ticks were obtained on Mt. Ophir, (= Gunong Ledang), Johore, about 125 miles south of Gunong Benom (Malayan Tick Survey data, September 1968). On Mt. Ophir, *D. compactus* appears to be more numerous in relation to *D. atrosignatus* than in any other Malayan locality known to us. Of 1253 ticks of both species taken from Mt. Ophir forest vegetation, 698 (56%) were *D. atrosignatus* and 555 (44%) were *D. compactus*. The altitudinal distribution of these samples was as follows.

altitude (ft)	number collections	number <i>D. atrosignatus</i>	(%)	number <i>D. compactus</i>	(%)	total
1000	3	98	(50%)	97	(50%)	195
1500	4	155	(64%)	86	(36%)	241
2000	5	217	(68%)	103	(32%)	320
2500	3	73	(38%)	119	(62%)	192
3000	1	8	(42%)	11	(58%)	19
3500	4	114	(54%)	99	(46%)	213
4000	2	33	(45%)	40	(55%)	73
total	22	698	(56%)	555	(44%)	1253

The 46 to 58 percentages recorded for *D. compactus* in relation to *D. atrosignatus* at altitudes above 2500 ft on Mt. Ophir are in sharp contrast to the data from Gunong Benom. A comparative environmental study of altitudinal forest zones on Gunong Benom and Mt. Ophir might yield data showing the basic ecological requirements of each species and reasons for the disproportionate numbers of *D. compactus* at all levels and especially at upper elevations of Mt. Ophir.

Dermacentor compactus Neumann

Collections from sweeping forest vegetation and from hosts (examined/infested) are as follows:

Sus scrofa (2/2), 800 and 1400 ft, 11♂, 5♀

Vegetation, 500 to 2500 ft, 45♂, 56♀

Vegetation, 2600 to 5200 ft, 1♀

For comments on these collections, see text on *Dermacentor auratus* group and *D. atrosignatus*, and also Tables 1-3.

Amblyomma testudinarium Koch

Collections from sweeping forest vegetation and from hosts (examined/infested) at various altitudes are as follows:

- Sus scrofa* (2/1), 800 ft, 1 nymph
Man (biting), 2500 ft, 1 nymph
Man (crawling on), 700 and 1500 ft, 1♂, 2♀
Vegetation, 500 to 2500 ft, 25♂, 20♀, 2 nymphs
Vegetation, 2600 to 5200 ft, 5♂, 3♀, 1 nymph

A. testudinarium occurs practically everywhere in Malayan forests, though usually only in moderate numbers. The incidence on Gunong Benom is either lower than in most other forests of Malaya or collections were made here at periods when adults and other stages were relatively inactive. Forty-seven specimens were taken from vegetation up to 2500 ft, and 9 at higher altitudes.

Only 1 nymph was found on the 2 *Sus scrofa* examined. *Sus scrofa* is the chief host of adult *A. testudinarium* in Malaya and elsewhere in Asia. The incidence of infestation of Malayan wild pigs is usually almost as high as that of *Dermacentor* ticks but the numbers of adult *A. testudinarium* on each pig are almost invariably much lower (unpublished).

Other hosts of adults in Malaya are the tapir, tiger, sambar deer, pangolin, and domestic buffalo. We have records of 5 males, 5 females, and 1 nymph parasitizing human beings in Malaya. Adults also feed occasionally on the tortoise, *Testudo emys*, monitor lizard, *Varanus salvator*, and python, *Python reticulatus*, in Malaya (unpublished).

Immature *A. testudinarium* are the most catholic in host preference of all Malayan ticks. They often occur on domestic chickens, goats, dogs, sheep, and buffalo. While no larvae are recorded from human beings by the Malayan Tick Survey, these tiny ticks are easily overlooked and we suspect that infestation of people may be fairly frequent. A nymph was taken biting a person at 2500 ft. on Gunong Benom. The Hooper Foundation group working with the Gunong Benom Expedition experienced heavy infestation of several members by seed ticks (larvae), presumably *A. testudinarium*, at 3000 to 4000 ft during the wet March-April period but not during the dry month of February (N. J. Marchette, personal communication). Other Malayan hosts of immature stages are (INSECTIVORA), the common treeshrew (*Tupaia glis*); (CARNIVORA), the Malay bear (*Helarctos malayanus*), weasel (*Mustela nudipes*), Malay civet (*Viverra tangalunga*), common palm civet (*Paradoxurus hermaphroditus*) (frequent), small-toothed palm civet (*Arctogalidia trivirgata*), banded palm civet (*Hemigalus derbyanus*), tiger (*Panthera tigris*), leopard cat (*Felis bengalensis*) (frequent), black giant squirrel (*Ratufa bicolor*), three-striped ground squirrel (*Lariscus insignis*), common porcupine (*Hystrix brachyura*) (frequent), wild pig (*Sus scrofa*) (infrequent), mouse-deer (*Tragulus javanicus*) (frequent), cobra (*Naja naja*), monitor lizard (*Varanus salvator*), jungle fowl (*Gallus gallus*) (frequent), and crested green wood-partridge or roulroul (*Rollulus roulroul*). Aside

from immature stage hosts reported from Vietnam (Hoogstraal et al., 1968), these are almost the only records of immature-stage *A. testudinarium*.

Engorged *A. testudinarium* reach the largest size (25×20 mm) of any tick species in Malaya and a single female may deposit 10,500 eggs. One of us (M. N.) has collected several hundred larvae from forest vegetation a few inches to 3 meters above the ground in the vicinity of a pig wallow in Malaya. In view of the height to which questing larvae climb on plants, it is surprising that this stage is so seldom represented in tick collections from Malayan forest vegetation.

A. testudinarium inhabits forests from Ceylon and India to Borneo, Indonesia, Thailand, Vietnam, the Philippines, Taiwan, and southern islands of Japan. It has not been associated with diseases of man and lower animals.

Amblyomma geoemydae (Cantor)

Six ornate nymphs were collected from lowland forest vegetation and 1 ornate nymph from a coucal, *Centropus sinensis*, at 1000 ft.

A. geoemydae parasitizes chiefly reptiles, especially tortoises, *Testudo emys*, *T.* spp., and monitor lizards, *Varanus* spp., in Borneo, Java, Malaya, and the Philippines. Taxonomic problems concerning this species were discussed by Kohls (1957). Disease relationships have not yet been studied.

Amblyomma spp.

Unidentified *Amblyomma* specimens from Gunong Benom are 1 larva from *Echinosorex gymnurus*, 1 larva from *Rattus bowersii*, 1 nymph from *Centropus sinensis*, and 1 nymph from *Anthracoceros malayanus*.

DISCUSSION AND CONCLUSIONS

Ticks from sweeping vegetation

Sweeping (flagging) yielded 546 ticks in lowland forests, 416 in mountain forests, and none in mountain mossy forests (Table 1). Of 5 tick species usually taken in greatest numbers by sweeping vegetation in Malayan forests [*Dermacentor atrosignatus*, *D. compactus*, *Haemaphysalis nadchatrami*, *H. semermis*, and *Amblyomma testudinarium*], each is represented in varying proportions in both altitudinal regions in which ticks were found. The reduction in numbers of *D. compactus* from 16% in lowland collections to 0.24% in mountain forests, was compensated in these zones by a rise in *H. nadchatrami* numbers, from 6% to 54%. As usual in collections from Malayan forest vegetation, *D. atrosignatus* comprised at least 40% of the specimens. No *Dermacentor* were found above 4000 ft. Only *H. nadchatrami* and *H. semermis* were taken in the 4000 to 5200 ft range and, as already stated, no ticks were found above the latter level.

H. c. cornigera adults and nymphs were also collected from lowland vegetation. Reasons for the apparently erratic distribution of *cornigera* in Malayan forests are not known. The collection of nymphs of *A. geomysdae* from vegetation is unusual in our experience. The presence of 2 exceptionally rare species, *H. hylobatis* and *H. calvus*, among ticks from vegetation is notable. Reasons for the paucity of *H. koningsbergeri* in collections from Malayan forest vegetation, in areas where this species is believed to be relatively common on small carnivores, remain to be investigated. *Ixodes granulatus*, a medically important parasite of small, ground-feeding animals, is unrepresented in tick samples from forest vegetation; it is a nidicolous species that rarely if ever quest from vegetation.

Ticks from vertebrate hosts

Almost all vertebrates examined for ticks on Gunong Benom were in lowland forests (Table 2).

Bats of the genera *Penthetor* and *Rhinolophus* were infested by larvae, nymphs, and females of *Ixodes simplex*, which has not previously been recorded from Malaya.

The single insectivore, a moonrat, carried *I. granulatus* adults and immature stages, and an *Amblyomma* larva.

Certain rodents yielded a few larvae and nymphs of *H. nadchatrami*, *H. semermis*, *H. koningsbergeri* (tentative identification), *D. atrosignatus*, *D. sp.*, and *Amblyomma* sp., and adults of *I. granulatus*. Many rodents were not tick-infested at the time of examination (see footnote, Table 2). The feeding period length of many tropical forest larvae and nymphs should be studied in detail to determine whether comparative rarity of finding these stages on small mammals may be explained by rapid feeding and early dropping from the host.

Each of the 5 wild carnivore species examined was parasitized by adults of *H. koningsbergeri*; a leopard cat was also infested by adults of *H. asiatica* and *H. semermis*, a binturong by adults of *H. hylobatis* and *H. semermis*, and a banded palm civet by nymphs and larvae of *H. vidua*. Lord Medway's dog yielded adult *H. koningsbergeri* and *H. semermis* and larval *D. sp.* Dogs of aborigine villagers bore adults of *H. koningsbergeri* and adults and nymphs of *H. bispinosa*, a parasite that has been introduced into Malaya and seldom infests wild forest animals in this country.

The common large mouse-deer, *Tragulus javanicus*, was parasitized by nymphs of *D. sp.* and *H. nadchatrami*, adults, nymphs, and a larva of *H. semermis*, and, as usual, by all stages of *H. traguli*. One smaller mouse-deer, *T. napu*, yielded only a single larva of *H. nadchatrami* (tentative determination). The comparatively heavy infestation of the 2 wild pigs, *Sus scrofa*, by adults of *D. atrosignatus*, *D. compactus*, *H. nadchatrami*, *H. semermis*, and *A. testudinarium* (in this exceptional case only by a nymph) is typical of Malayan collections from this host.

Six of the 9 birds examined on Gunong Benom were infested by specific bird parasites, *H. doenitzi* and *H. wellingtoni*, and by a few *Amblyomma* nymphs,

including 1 of *A. geoemydae*. A more extensive study of bird-tick interrelationships on Gunong Benom would be certain to be rewarding.

Ticks biting human beings in lowland forests were adult *H. nadchatrampi* and *H. c. cornigera*, adult and nymphal *H. semermis*, and nymphal *A. testudinarium* and *D. atrosignatus*. Adults of these species (except *H. c. cornigera*) and a nymphal *D. atrosignatus* were also collected while crawling on people. At 6000 ft, an adult *H. nadchatrampi* was removed while biting and at 3000 ft an adult *H. hylobatis* was crawling on an expedition member. Numerous larvae, presumably *A. testudinarium*, infested persons working at the 3000 to 4000 ft level in the rainy season but not during the dry month of February.

Medical relationships

Owing to the relatively undisturbed forest environment of Gunong Benom and to the continuity of forest from lowlands to altitudinal zones above those inhabited by most Malayan ticks, this mountain area is eminently suitable for investigating the natural history of "primitive" cycles of tickborne pathogens infecting man and lower animals. Among the tick species found here, *Ixodes granulatus* is the original source of the virus (Russian spring-summer encephalitis complex) causing Langat encephalitis. This virus can be transmitted experimentally by other tick species, a finding/that enhances interest in its more widespread presence in nature (see Hoogstraal, 1966). *I. granulatus*, *Dermacentor* spp., and *Haemaphysalis* spp. [including *H. nadchatrampi* and *H. semermis*] have been shown by Marchette (1966) to be involved in the cycles of tick typhus (*Rickettsia* sp.) and Q fever (*Coxiella burnetii*) in climax forests of Malaya. Lanjan virus, first recovered from *Dermacentor* sp. from Bukit Lanjan near Kuala Lumpur, has recently been isolated from Malayan *I. granulatus* and *H. semermis* (N. J. Marchette, personal communication). Other tick species that should be studied epidemiologically are *H. bispinosa*, owing to its close association/with domestic animals, *H. koningsbergeri* in relation to *Babesia* infections of carnivores, *H. doenitzi* and *H. wellingtoni* to determine their virus-vector potential among wild and domestic birds, and *H. traguli* in relation to infections in the mouse-deer. The question of virus infections in wild pigs and their chief tick parasites, *D. atrosignatus*, *D. compactus*, *H. nadchatrampi*, *H. semermis*, and *A. testudinarium*, should also be investigated.

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